BUTTER AND FATS.

To Distinguish one Fat from Another by Means of the Microscope.

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[PLATE VI.]

A little over ten years ago I made my first experiments relating to oleomargarine and butter, my prime object being to find a mode by which I could distinguish these substances one from the other.

My first paper on this subject was illustrated by several cuts, and published in the New York *Quarterly Microscopical Journal*, as early as 1876.

My second paper was written in answer to a request of the Committee on Manufactures of the House of Representatives, during the session of 1876 and 1877, the committee having sent to the Commissioner of Agriculture two samples of a butter-like substance to be examined by the "microscopist" of the Department, with the request that he should decide whether the substance was butter or oleomargarine. I made the examination, and reported that both samples were oleomargarine. Soon afterward, two members of the committee called and examined my modes of detecting butter substances and substitutes, and expressed themselves perfectly satisfied with my report, they having been aware from the first that the samples sent by them were oleomargarine.

My third report on butter and fats was published by the Department last year (1884), and is illustrated by six cuts—chromolithographs.

There has been a considerable demand for this paper from various classes of persons, including dairy commissioners, milk inspectors, produce dealers, officers of boards of health, physicians,

professors in colleges and universities, microscopists, chemists, and others.

Since the publication of that paper, I have experimented largely with butter, and have made the discovery that when it is boiled and cooled slowly for a period of from twelve to twenty-four hours at a temperature of from 50° to 70° Fahr., it not only becomes crystallized, but with proper mounting and the use of polarized light it exhibits on each crystal a well-defined figure resembling what is known as the cross of St. Andrew. (*Fig. 7.*) In course of time, the period ranging from a few days to a few weeks, according to the quality of the butter used and the temperature to which it is exposed, the crystals, which at first are globular, degenerate, giving way to numerous rosette-like forms peculiar to butter. (*Fig. 9.*)

I have also demonstrated that the respective crystals of butter, beef, lard and other fats differ essentially from each other, and may be distinguished at once one from another when properly prepared. The crystals of newly-made butter when boiled are globular and present a dotted appearance, which may be due to the projection of numerous spines, so small as to be scarcely visible even with the high power of the microscope. Those of beef have long bi-serrated spines proceeding from a common center, while pressed lard gives a strictly stellar or star-like form proceeding from a dense opaque center which appears to be granulated. Boiled lard fails to show an opaque center.

These new facts led me to experiment with other fats, vegetable and animal, with a view to determining whether the fats of other animals and vegetables may not also have crystalline forms peculiar to themselves, and of such definite structure as might lead to their detection, when fraudulently combined with other fats, in medicinal compounds, etc. I have made numerous experiments to that end, and I find as a result of these investigations, that the normal crystals of several fats which have not heretofore been examined with sufficient accuracy, may be determined from all others thus far examined. For example, I find that cocoa butter, when its consistency is very much reduced with sweet oil by means of heat, gives a most beautiful and perfectly formed crystal. Spermaceti, white beeswax and paraffine, treated in the same way, give other forms,

but as yet I am unable to obtain the highest crystalline forms of these last mentioned fats.

The value of my investigations in animal and vegetable fats, may be inferred from the fact that in each of the prosecutions lately brought against fraudulent butter dealers and venders in the city of Washington, D. C., the accused in every instance acknowledged that my evidence against them was correct, and that they had sold tallow compounds as butter.

As a consequence of my success in detecting these fraudulent compounds, about sixty hawkers, men and women, who, under the guise of farmers, have been offering for sale from door to door in this city, compounds of tallow, lard and cotton-seed oil, mixed with inferior butter, as genuine creamery butter, have abandoned their calling, to the great benefit of the dairy interests of this section of the country.

General Examination of Butter and its Substitutes by the Naked Eye.

In making examination of butter and its substitutes without the aid of the microscope, I first place a specimen of the suspected article between two small pieces of glass, using for one the ordinary microscopic slide, 3 by 1 inch, and for the other a thick microscopic cover. I then compress the specimen sufficiently to give a thin, translucent cloud. If white, opaque particles are observed between the glasses, there is reason to believe that the substance is a foreign fatty compound. If the experimenter will first practice with lard, in an atmosphere of moderate temperature, he will observe the white specks of fat alluded to. Should the cloud be very even throughout, it is probably pure butter, or newly-made butterine.

Before using the microscope, I usually subject a portion of the samples submitted for examination to my sulphuric acid test. (See Sulphuric Test.)

While these two simple tests will always distinguish true oleomargarine from butter, their result is less decisive in the case of butterine, owing to its containing a considerable proportion of butter. Hence it is is often necessary to subject what appears to be genuine butter to a closer examination. When this is the case, I resort to the microscope.

Microscopic Test.

Prepare the sample by first removing any salt present by pressing a portion of the substance through the meshes of fine cambric muslin; then mount the specimen, with as little friction as possible, and view it by plain transmitted light, under a power of about 75 diameters. If well-defined crystals of fat are present they are at once seen. Should fat be in the amorphous state, it will not be observed in this way. I then resort to polarized light, when very minute, fatty bodies, whether in the amorphous or crystalline state, are at once detected, if present. For this purpose the polarizer is rotated until its face angle is at right angles to the analyzer. Push the polarizer down as low as the stand will permit; by this means a darker ground is produced, and the bright specks or light shades of fat will appear over the dark ground. When these amorphous fatty bodies are found, a selenite plate should be used in connection with the polarizing prism. With this combination a brilliant display of prismatic color will be seen. (*See fig. 16.*)

When it is desirable to ascertain whether they are of beef or lard, boil about one ounce of the substance, and cool it slowly. The next step is to examine a portion of it, thus prepared, under the microscope. When permanent specimens are desired it will be necessary to prepare, by any of the well-known means, on a glass slide of 1 by 3 inches, a varnish ring one one-hundredth of an inch in thickness. When dry, put a single drop of any thick, transparent oil within the circle, and place in contact with the oil a very small portion of the suspected substance. Use a needle, to separate the floating fatty substance into very fine granules (crystals). Place a suitable glass disc or "cover" over the oil and press it gently down, so that it will come in contact with the varnish ring, which should receive one coat of varnish just before the slide is used. The ring should be of sufficient thickness to protect the crystals from pressure by the cover. The object may now be viewed by plain transmitted light. If the crystals exhibit a well-defined stellar form, such as *figs. 13* or *14*, the substance is lard. If such as *18*, it is beef fat. But the latter should be viewed with the high power of the microscope with polarized light, so as to observe the bi-ser-

rated form of the individual spines, of which the perfect crystals consist. If butter crystals are present they can at once be distinguished.

How to Crystallize Butter and other Fats, and Separate the Crystals so as to be Seen with the Naked Eye, or Pocket Lens.

Procure a specimen of pure butter, and boil it in a test-tube or iron pan for a period of several seconds; pour the liquid portion off into a cup or other suitable vessel, and put it in a cool place to crystallize. I generally allow the cooling process to continue from twelve to twenty-four hours. Remove with the point of a penknife a few grains of the butter thus treated, place it on a slip of glass and pour over it a few drops of alcohol. The crystals may then be easily separated from each other by means of a needle. A solution of alcohol in a concentrated solution of pure carbolic acid, *i. e.*, the proportion of ten parts by measure of the first, to one part of the last, will prove more satisfactory in separating the crystals than alcohol alone. If the crystals are viewed by a pocket lens, they will appear like so many insect eggs. (*See fig. 1.*) Beef and lard fats may be treated in like manner, but in practice it will be found that the crystals of these fats are not so easily separated, owing to their long spines interlocking with each other. Treated in this way, the fatty crystals will be seen very well with a pocket lens.

About ten years ago, while making some experiments with boiled butter, I first observed it exhibited small crystals somewhat stellar in form, but gave no further attention to the fact until May last. For the purpose of determining the real form of the crystal of boiled butter, I procured a sample of pure dairy butter from Ohio. I boiled it, and, when cold, examined it under a power of 75 diameters. To my surprise I found globular bodies. When I subjected them to polarized light, a cross, consisting of arms of equal length, was observed on each crystal. (*See figs. 2, 3, 5, 6 and 7.*) On rotating the polarizer the cross of each crystal rotated. On rotating the glass on which the specimen of butter was mounted, the crosses remained stationary, thus showing that the appearance of the cross depends, probably, on the fact that the crystals are (1) globular, (2) polarizing bodies, (3) translucent, and (4) comparatively smooth. Were they opaque or non-polarizing, or did they

consist of long spines, causing great divergence of the rays of light, no image of the cross would be visible; showing that the appearance of the cross under polarized light and the conditions stated are not due to any physical cross structure on the fatty crystals themselves. But from whatever cause the appearance of the cross on the butter crystals arises, its constant appearance on new butter under the conditions above described is a fact beyond any question; and, as far as my experience goes, the better the quality of the butter the more clearly defined is the cross: it is black, large and well defined. When these crystals are under polarized light and a selenite plate, combined, they exhibit the prismatic colors, but the cross proper is not visible in this case, although the crystals are still divided into four equal parts and are exceedingly interesting objects. (*See fig. 10.*)

In order to leave no room for doubt respecting these globular crystals being peculiar to butter, I had cream churned through the kindness of Mr. Frank K. Ward, of this city, and a fine sample of granulated butter made in my presence, a portion of which was secured, also a portion of butter from another lot made in my absence. The first lot was made of pure Alderney cream, the second from mixed cream. The samples were kept apart in separate boxes, boiled, cooled slowly, and examined after my usual modes. Both samples gave the globular crystals, showing the cross. These crystals varied in diameter from fifteen ten-thousandths to one one-hundredth of an inch. Large crystals, such as the latter, show the cross but dimly, while the small ones show it distinctly.

The Butter of Several States Examined.

To this date I have received several samples of butter from Tennessee, Ohio, New York, Maryland, Virginia and the District of Columbia. All exhibited one or both forms of the crystals common to butter, but generally the globular only. Pure market or store butter which has been exposed to high temperature for several months, exhibits a greater number of the rosette forms, measuring only about fifteen ten-thousandths of an inch in diameter. In general it may be said that as butter loses its freshness, either through age, heat, or other cause, the globular crystals of boiled butter seem to bud or send forth a small rosette crystal appearing always in the

center of the globule. (*See fig. 5.*) Inferior butter appears to resolve more quickly into the rosette-like forms than the highly fatty butters of the best quality. (*See figs. 8 and 9.*) These latter forms appear to result from the breaking up of the globular crystals, in the center of which speck after speck will appear to expand into the rosette shape, and float away in the oil in which they are mounted. (*See figs. 5, 8 and 9.*) In examining the two butters received from Mr. Ward, I observed they differed materially from all others received; the crystals being darker in color generally, and larger.

The butter received from Franklin Brothers, Jefferson County, Tennessee, exhibited a peculiar indentation in the large crystals; and so well defined is this peculiarity that this brand may at once be distinguished from all others I have yet examined. (*See fig. 6.*) All butters examined in May last, made from milk of cows fed on dry feed, exhibited crystals more brilliant in appearance than those fed on grass in July, August and September, and contained more solid fat. I think it probable that the butter crystals of different breeds may yet be distinguished from each other by some marked peculiarities, although preserving, always, well-defined features common to butter.

The globular crystals of butter, grass fed, are exceedingly transparent; in this case a very low power of the microscope should be used for examinations. I have found an inch-and-a-half objective answers the purpose.

Exceedingly small globular butter crystals may arise from one or two causes, such as using very oily butter, or by cooling the boiled butter too quickly. All boiled samples should be kept in a dark cool place, to prevent the crystals from passing to the secondary stage, characterized by the rosette forms. Should these precautions be neglected, effective crystallization will not take place, and the cross will not be easily discovered. At high temperatures, say 100° Fahr., the globular crystals of butter generally dissolve.

Mounting Butter Crystals.

A practical microscopist will readily perceive that from the very nature of the crystals great care must be exercised in mounting them. The globular crystals should not be compressed; neither should they be exposed to light, except when necessary, or to a

temperature of over 70° or 75° Fahr. At 95°, I found the crystals of the Franklin, Tennessee, butter dissolve, while the "Ward butter" crystals at the same temperature retained very nearly their normal form.

In order to cystallize solid fats, such as beef, and show their normal crystals, it is necessary first to boil them with sweet oil. When cold, the composition should be of the consistency of butter. Cocoa butter and the fat of the tallow tree of China should be made so liquid, when cold, that its crystals will swim incrusted on the surface of the oil; this will take place always, provided the oil, while hot, is saturated with the tallow. When a little of this floating incrustation is bruised gently in oil and mounted, beautiful crystals will appear under the microscope. Normal crystals of fat of any description mounted in oil are difficult to preserve for a long period, owing to their tendency to dissolve in the oil in which they are mounted, especially at temperatures exceeding 80° Fahr.

Sulphuric Acid and Other Tests for Butter, Oleomargarine and Butterine.

Oleomargarine made under the French patent, consisting mostly of beef fat, is easily detected by pouring a few drops of concentrated sulphuric acid on a portion about the size of a bean, and mixing them quickly with a glass rod. The mass at once assumes a light amber tint, soon turning darker and richer in color. After a period of from fifteen to thirty minutes it turns to a well-defined crimson-scarlet; after a lapse of twenty-four hours it becomes the color of dark walnut, and remains of that tint. Within the last six months I have failed to find any of this grade of butter substitute in Washington markets. It is giving way to various cheaper compounds, known as butterine.

True oleomargarine may be detected also by boiling a sample of it in an iron spoon, when the odor of burnt fat is given off. Butterine cannot be detected by this process satisfactorily, owing to the presence of butter in the mixture, the butyric acid of the butter being the most prominent odor observed.

If samples of pure butter, oleomargarine and butterine are exposed to a temperature of 75° Fahr. for a period of one hour, the last named will become slightly glossy, and at 85° will become almost semi-fluid, while the other two samples named will not appear, to

the naked eye, to be thus affected, and will preserve their sharp angles.

When oleomargarine or butterine is newly-made, crystals of fat are seldom observed in it, when viewed under the microscope; but in course of time, owing to their being subjected to light, and increasing rise of temperature in the stores, both exhibit crystals of fat more or less. In the butter substitutes of commerce, the crystals are seldom absent, and dark, nitrogenous, yellow, translucent bodies are always seen in them and are characteristic of them. These latter substances are never found in pure butter. When a butter substitute is sold as butter, and exhibits only the faint odor and taste of butter, and one is puzzled to know whether it is genuine or not, it will generally prove to be either oleomargarine or butterine. When the suspected substance has a bad odor and tastes like butter, it is probably old butter, provided it exhibits no dark yellow bodies when viewed under a power varying from 75 to 250 diameters.

How to Detect the Crystals of Lard by the Eye, Unaided by a Lens.

Procure a piece of glass. Place a small portion of the lard upon it, covering it with a thick microscopic glass disc; press the parts together so as to form a thin film of the lard between, as described in the case of butter. View the glass and lard thus secured before a strong light, when white specks will be observed in the lard. The transparent portion represents the oil—the white specks the crystals of fat. In this way, fats may frequently be detected in oleomargarine and butterine. Pure butter treated in this way exhibits a plain even cloud. Mixed butters have a streaky appearance, owing to their different densities and colors.

General Notes.

Oleomargarine when made under the formula of the French patent, is composed mostly of beef fat churned with milk and colored with annotto. Very little of this composition is now manufactured in the United States; it is giving way to butterine.

Butterine is said to be composed of lard four pounds, tallow four pounds, and creamery butter two pounds. A lower grade is made as follows: Cotton-seed oil, four pounds; tallow, four pounds; low grades of butter, two pounds. It will be seen from the two

compositions of butterine above quoted, that the sulphuric acid test would act differently in each case. I, therefore, advise the polariscope test as the most effective for these compositions, boiling all samples, after having tested the sample as found in the market for sale. In this way all of the fats contained in the sample will be crystallized. These should be examined as described.

A composition of butter and lard sold as oleomargarine, but in reality butterine, was sent to me and examined. In this case the butter used was probably in larger proportions than the lard. When viewed by polarized light only, it exhibited the cross of pure butter, while the crystals were covered with the spines of lard modified by the butter. (*See fig. 11.*) With selenite plate it appeared like *fig. 12.*

All butter and fats when boiled, should be strained while hot, to remove coagulated albuminous bodies.

Illustrations of Fatty Crystals. Butter, Lard, Beef, Oleomargarine and their Imitations.

Fig. 1. Represents a number of boiled butter crystals as seen by a low power.

Fig. 2. A crystal of Tennessee butter, boiled, as seen under polarized light, showing the cross of St. Andrew. Breed, Tennessee native, and shorthorn Devonshire.

Fig. 3. A crystal of Ward's "Alderney" butter, boiled, Washington, D. C.

Fig. 4. A crystal of butter highly magnified, boiled.

Fig. 5. A crystal of Tennessee butter, boiled, exhibiting the second stage of crystallization in progress. See small rosette crystals growing from center of globose crystal.

Fig. 6. A crystal of Tennessee butter, boiled, exhibiting an indented crystal, a peculiarity of this butter.

Fig. 7. A crystal of Ohio butter, boiled (Huron County); color, white.

Fig. 8. Secondary rosette crystals of boiled butter as seen under polarized light and selenite plate.

Fig. 9. Secondary rosette crystals as seen by polarized light without selenite plate.

Fig. 10. A crystal of boiled butter as seen under polarized light and selenite plate.

Fig. 11. A crystal of boiled butter and lard combined, sold as oleomargarine. The cross represents the presence of butter, the spines that of lard, as seen under polarized light.

Fig. 12. A crystal of the same compound (butterine), as seen under polarized light and selenite plate.

Fig. 13. A crystal of pressed lard, with dark center.

Fig. 14. A crystal of boiled lard, strained.

Fig. 15. A crystal of boiled lard, strained, as seen under polarized light and selenite plate.

Fig. 16. Oleomargarine or butterine, as seen under polarized light and selenite plate. The fat in this case is in a homogeneous state.

Fig. 17. Specimen of pure butter, free from salt or other particles, as seen under polarized light and selenite plate. In this case the shade of color depends on the selenite plate. It may be red, green, blue or other color, but will always have an even shade in the case of pure butter.

Fig. 18. A normal crystal of beef fat, very highly magnified. The crystals of beef vary in structure, but they preserve uniform characteristics.

All the butters illustrated in this plate have been made from the milk of dry-fed cows.

When cows are fed on green feed, the butter is more oily; in this case, the cross is not so well defined under the conditions stated. Very oily butter should be viewed under a power of about twenty diameters. In this way the cross will be seen. They will rotate or appear to do so, on rotating the polarizer or analyzer.

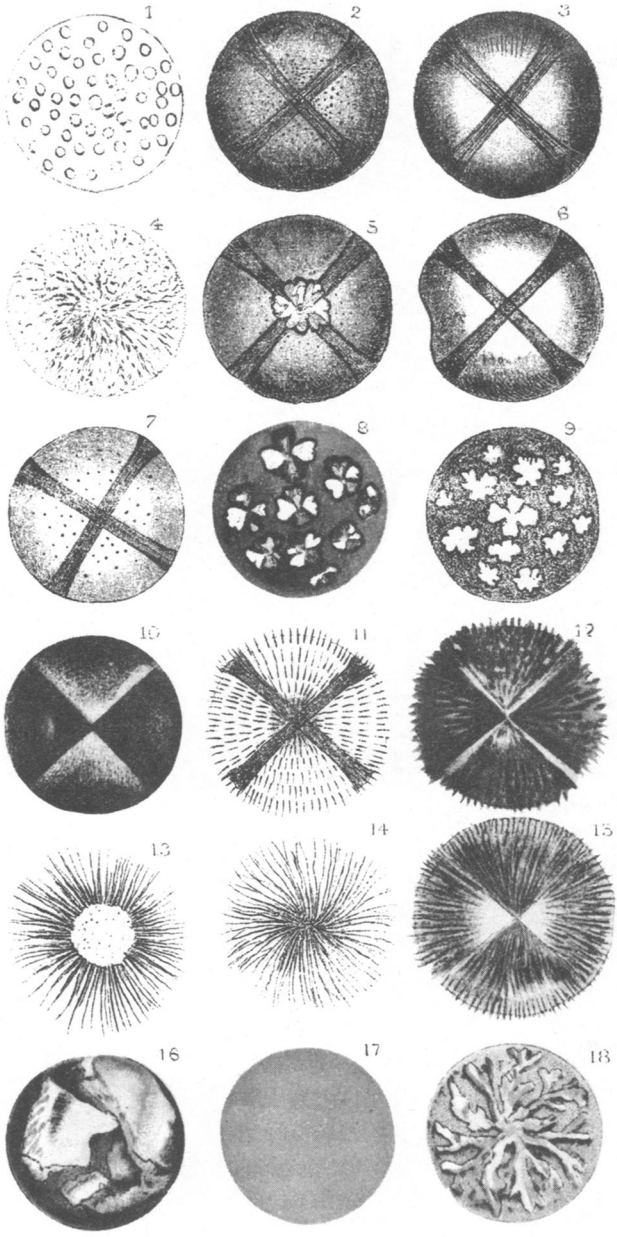
Beef fat, reduced to the consistency of butter by heat and the admixture of sweet oil, and cooled, when viewed by plain transmitted light, will appear as simply mottled, brown nitrogenous bodies, destitute of structure; but when viewed under a power varying from 500 to 1000 diameters will give defined crystals, resembling *fig. 18*, more or less, having branched spines, serrated and bi-serrated.

My discovery that the respective fats of animals and vegetables differ so essentially from each other, opens up a new field of investigation, and gives great promise of future discoveries in this line.

CRYSTALS OF FATS, BUTTER, BEEF & LARD.

Representing Butter, Oleomargarine & Butterine.

PLATE **VI.**



ERRATUM.—For Plate I., fig. 9, read Plate II., fig. 9.

PLATE VI., to face page 138, illustrating Dr. Taylor's paper will be furnished to members as soon as procured by the Publication Committee.